PROCEEDINGS

OF

THE ROYAL SOCIETY.

February 16, 1893.

The LORD KELVIN, D.C.L., LL.D., President, in the Chair.

A List of the Presents received was laid on the table, and thanks ordered for them.

The following Papers were read:—

I. "On a Portable Ophthalmometer." By THOMAS REID, M.D. Communicated by LORD KELVIN, P.R.S. Received January 1, 1893.

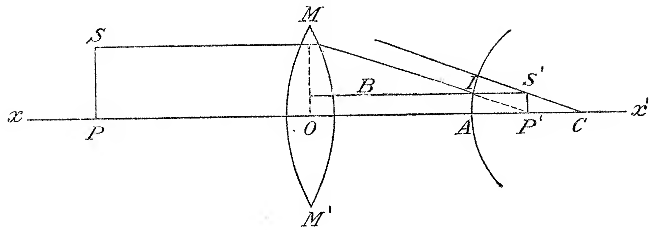
The object of the instrument about to be described is to measure the curvature of the central area of the cornea, the polar or optical zone; or of any spherical reflecting surface of from 6 to 10 mm. of radius. In its present form the instrument can only be applied to the measurement of the corneal surface in the visual line. As this is the area of the cornea utilised for distinct vision, this instrument furnishes all the data practically requisite for the diagnosis and measurement of corneal astigmatism.

The theory of its construction is based on a particular application of the following well-known optical law: that when two centred optical systems are so combined that their principal foci coincide, the ratio of the size of the object to the size of the image formed by the combined systems is equal to the ratio of the principal foci of the two optical systems, adjacent respectively to object and image. The two optical systems in this case are the convex lens of the instrument and the cornea as a reflecting surface, with the object in the principal focus of the adjoining optical system.

Thus:—(*vide* fig. 1).

Let MM′ be the convex lens of known focus, A the corneal surface, and P′ the point where their principal foci coincide.

Fig. 1.



Let SP be an object situated at the principal focal distance of MM′, and let XX′ be the principal axis of the system.

Then a ray SM parallel to the axis will, after refraction, be directed to the principal focus P′ of the curved surface of the cornea, and therefore be reflected in the direction IB parallel to the axis XX′. IB prolonged will meet the ray directed to the centre C at the point S′; therefore S′ is the image of S, and S′P′ the image of SP, and S′P′ is in the principal focus of the convex reflecting surface.

In the similar triangles MP′O and IP′A,

$$\frac{\mathrm{P'O}}{\mathrm{P'A}} = \frac{\mathrm{MO}}{\mathrm{IA}},$$

SM and IS′, the prolongation of the reflected ray, are parallel to the axis XX′,

therefore $\mathrm{SP} = \mathrm{MO}$ and $\mathrm{S'P'} = \mathrm{IA}$.

Therefore $$\frac{\mathrm{P'O}}{\mathrm{P'A}} = \frac{\mathrm{SP}}{\mathrm{S'P'}} \quad \text{or} \quad \frac{\mathrm{O}}{\mathrm{I}} = \frac{\mathrm{F}}{f}.$$

$$f = \frac{r}{2};$$

therefore $$\frac{\mathrm{O}}{\mathrm{I}} = \frac{2\mathrm{F}}{r} \qquad \text{(I)};$$

therefore $$r = \frac{2\mathrm{F} \times \mathrm{I}}{\mathrm{O}}.$$

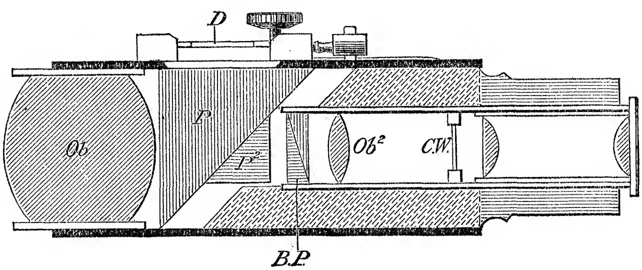
Description of the Instrument.

The essential parts of the instrument are an aplanatic convex lens of known focus, a rectangular prism neutralised in its centre by a smaller prism, one side of the rectangular prism being adjacent to the lens and a circular or other disc being opposite the other side in the principal focus of the lens. When the instrument is held in front of the convex reflecting surface with the disc turned towards a luminous

source, a virtual image of the disc will be formed at the virtual focus of the convex reflecting surface. This image will only be seen distinctly by the emmetropic eye through the neutralised portion of the prism, when the focus of the lens in front coincides with the virtual focus of the convex surface. The ratio of the object to the image will be as shown above. If now a double-image prism be inserted behind the neutralising prism, which exactly doubles this image, its power with the combination is easily determined, and therefore the exact size of the image can be measured. The size of the object being known, we have the three elements necessary for determining the fourth proportional, the curvature of the convex reflecting surface.

The instrument in this simple form presented a number of practical difficulties in its manipulation, which were overcome by the introduction of a short telescope behind, with double-image prism fixed in front of its object-glass.

FIG. 2.



In its present form the instrument consists of the following parts (*vide* fig. 2*) :—An aplanatic lens *Ob*, a rectangular prism P neu tralised in the visual axis by a smaller prism P^2 and a telescope, with the double-image prism BP fixed in front of the object glass of the telescope Ob^2. The focal length of the object-glass Ob^2 is precisely the same as that of the aplanatic lens *Ob*, and cross wires CW at its principal focus are viewed by a Ramsden eye-piece.

Before using the instrument it is necessary and sufficient that the cross wires should be distinctly seen at the punctum remotum of the observer. The adjusted instrument is held in the observer's left hand, which rests on the forehead of the patient, the disc being directed to a luminous source to the right of the observer. The point of coincidence of the principal foci is found by moving the instrument to and fro. When the observed eye is directed to the central or

* The object-glass has been specially constructed according to the formula of Professor Abbe, and contains barium glass as one of its constituents.

fixation point and his visual line is vertical to the point of the cornea through which it passes, the corneal image doubled and inverted ought to be seen in the centre of the field. Instead of using circular discs of different dimensions, the size of image required to produce exact contact in any meridian is conveniently and quickly obtained by making the required change in the size of a carefully constructed iris diaphragm. By using a circular object, the circular, elliptical, or irregular form of the image reveals at once the condition of the surface. When the image is elliptical, the meridian of greatest curvature is easily found by rotation of the telescope, and a rotation of 180° gives a controlling observation. By a similar process the meridian of least curvature is determined.

Graduation of the Instrument.

Let D be the power in dioptres of the cornea as a refracting surface, with a medium behind it of uniform density having an index of refraction $n = 1{\cdot}337$ approximately.

$$D = \frac{(n-1)\,1000}{r}$$

$$= \frac{337}{r} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{(II)}.$$

Combining equation (I) with (II),

$$D = \frac{337 \times O}{2IF},$$

$$D+1 = \frac{337 \times O'}{2IF},$$

$$1 = \frac{337}{2IF}(O'-O).$$

In the present instrument $I = 2$, and $2F = 52$,

therefore $$1 = 3{\cdot}24\,(O'-O),$$

$$\frac{1}{3{\cdot}24} = O'-O;$$

therefore $$1D = \text{rather less than } \tfrac{1}{3} \text{ mm}.$$

The index is divided into two parts, outer and inner. The outer registers the size of the image, and the inner the corresponding dioptres.

The degree of refinement with which the measurements may be carried out depends entirely on the degree of exactness of determina-

tion of the constants, especially I and F. I has been determined exactly to 1/500th inch, and can be estimated to about 1/1000th. The focal length of the object-glass can be determined by Cornu's method, but in general it is more convenient to measure two curved surfaces whose radii are exactly known, and within the limits of the instrument.

The index error is found by taking the number of dioptres at sufficiently great intervals within the limits of the instrument. In this instrument, if we take the extremes of the index, $0 = 12$ mm. and $0 = 16$ mm., we find the corresponding dioptres are 38·9 D and 51·84 D. The index being graduated in thirds of a millimetre, the index error of each division is nearly 0·08 D, which is positive.

If the double prism be now removed, the image being single, and the pupillary opening generally distinctly visible, it affords a means of determining whether the visual axis passes through the centre of the pupil.

It will be seen that this instrument differs from the ophthalmometer of Helmholtz, the most perfect instrument theoretically and practically which has been devised for this purpose, in which, while the object is constant, the image varies with the curvature of the surface, but always covers the same angular interval of the surface. It resembles the *ophthalmomètre pratique* of Javal and Schiötz, in which the doubling is effected by means of a double-image prism inserted between two achromatic lenses of equal focus, so that while the image is constant the object is made to vary. With this instrument, when the difference of curvature of the principal meridians is considerable, amounting to 3 or 4 dioptres, in order to obtain approximately accurate results it is necessary to insert birefractive prisms of different powers, giving images of from 1 to 3 mm. In the present instrument the image of 2 mm. has been selected as giving sufficiently accurate results for most practical purposes, measuring with precision, as it does, a difference of refraction of half a dioptre. For cases outside the limits already referred to (6 to 10 mm.) prisms of suitable powers can be substituted.

FIG. 2.